

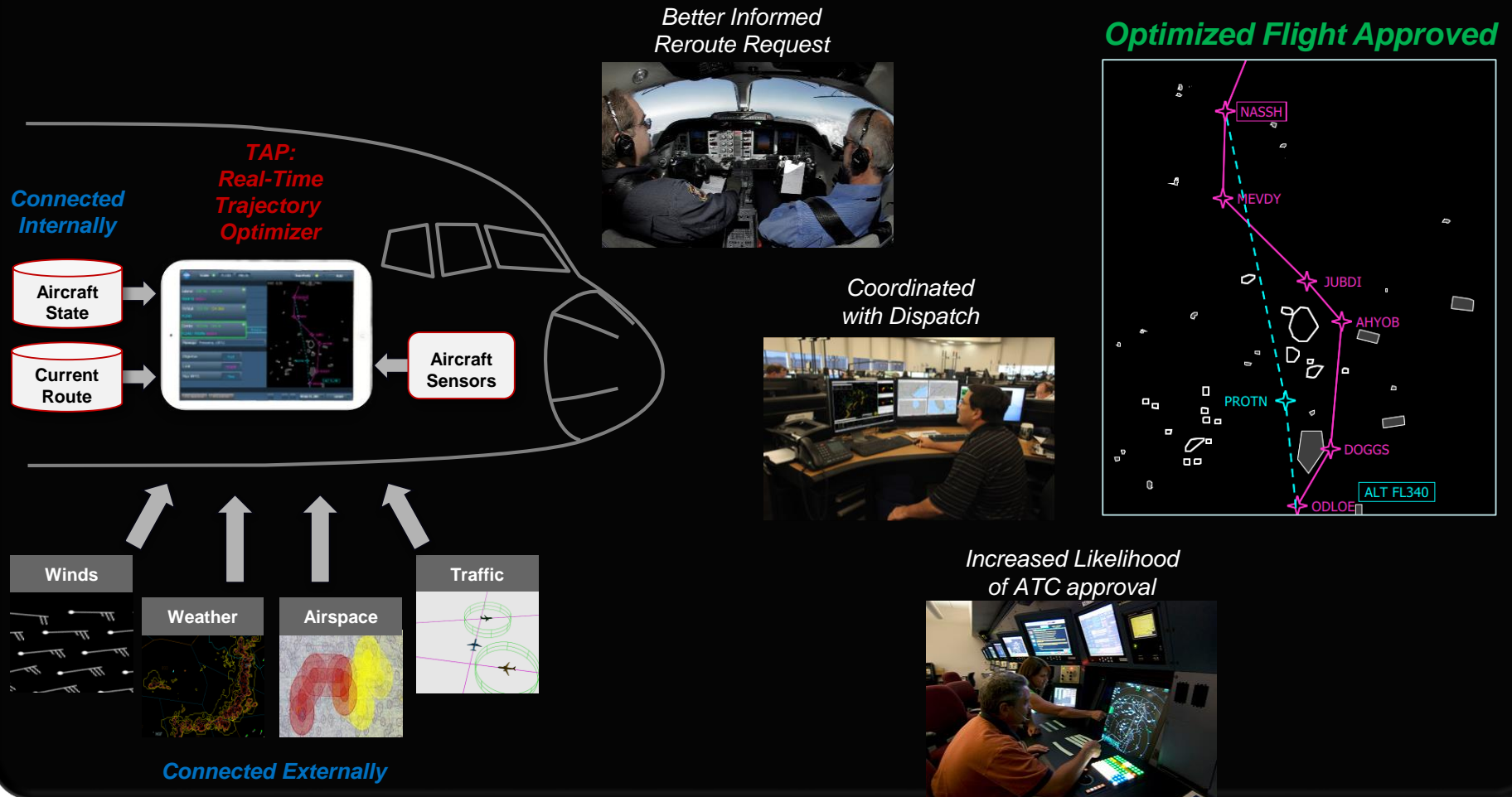
Flight Test Assessments of Pilot Workload, System Usability, and Situation Awareness of TASAR



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Traffic Aware Strategic Aircrew Requests

Cockpit **automation** and **connectivity** to real-time operational data are leveraged to enhance route-change procedures for **flight optimization**



Traffic Aware Planner (TAP) and the Emerging “Connected Aircraft”

Designed as an *Electronic Flight Bag (EFB)* application

Ownship data via standard avionics interfaces (read only)

Aircraft current state, active route, traffic data

Environment data via air/ground connectivity

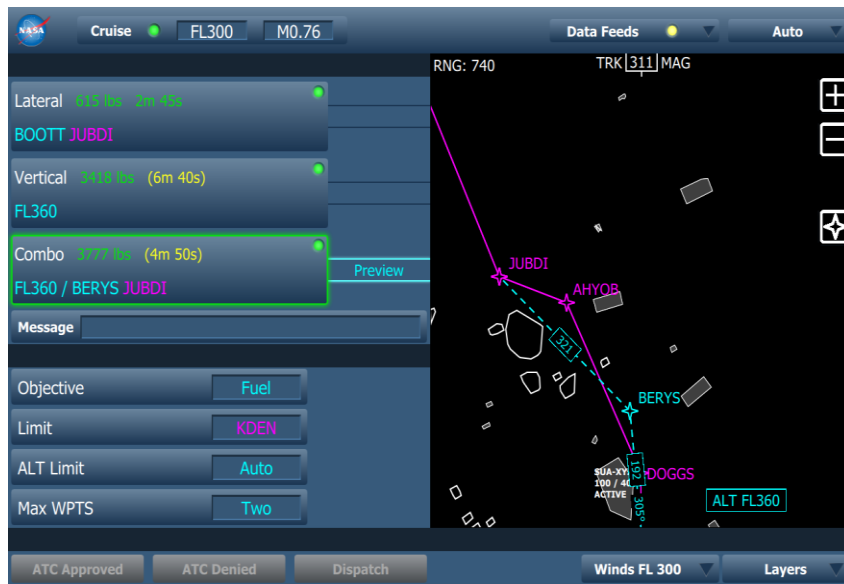
Latest winds, weather, airspace status, etc.



Two Modes of Operation

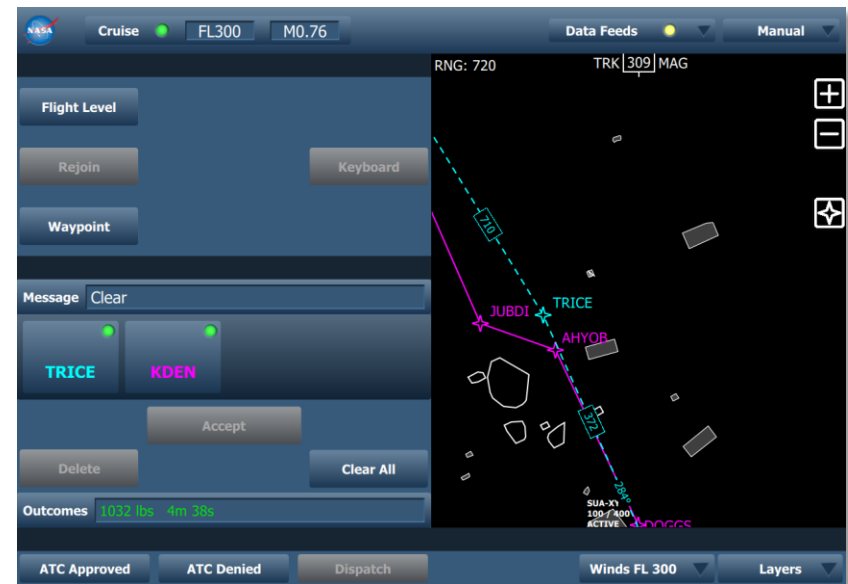
Auto Mode

Computes real-time route optimizations

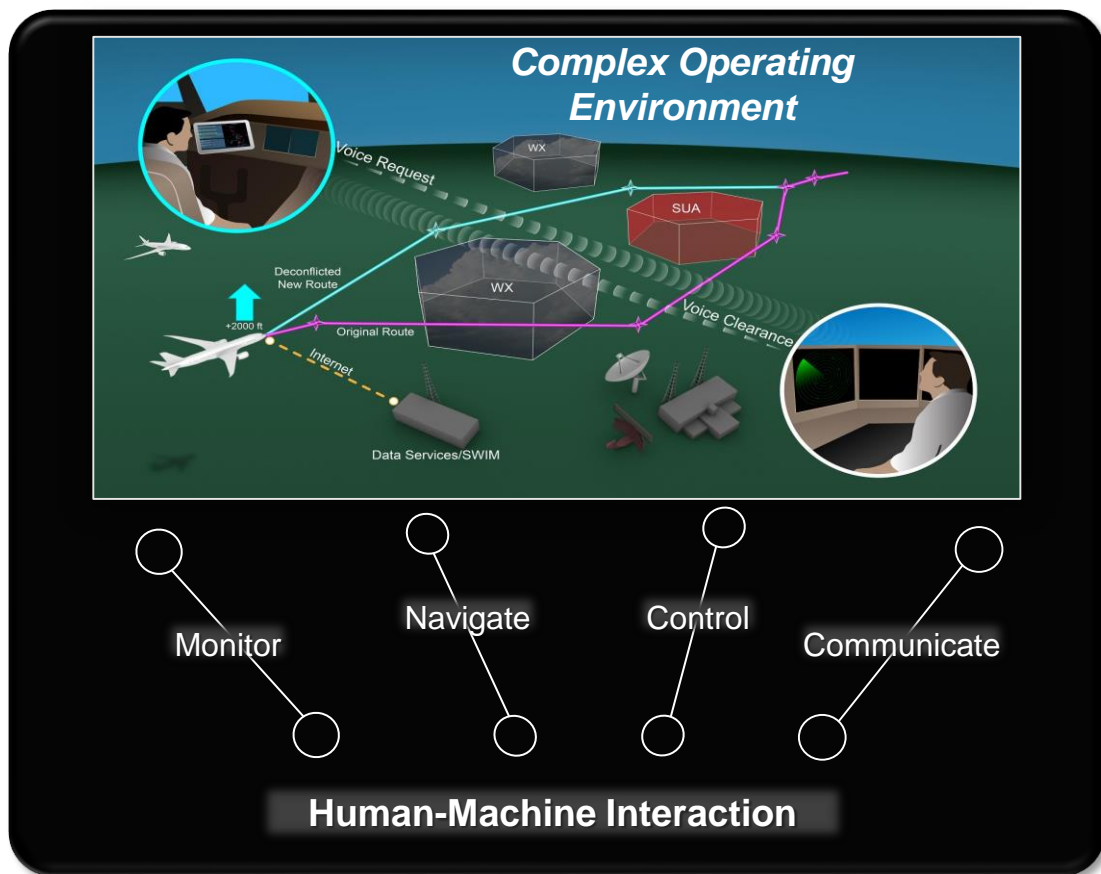


Manual Mode

Analyzes pilot-entered route changes

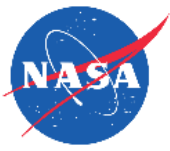


Flying an aircraft involves a complex, multidimensional series of behaviors, only some of which can be observed directly



- Cockpit procedures, technology, and instrumentation continue to change and become more complex
- New technologies require evaluation of the potential impact on pilot workload and situation awareness
- One method is the use of subjective assessments of workload and situation awareness

Flight Test Objectives



- *Conduct a human factors evaluation of the TAP software application and interface*
- *Investigate interaction with TAP Human Machine Interface (HMI) during normal flight operations*
- *Assess effects on perceived workload and situation awareness*
- *Assess system usability, comprehensibility, and usefulness*

TASAR Flight Tests in the National Airspace System

Nov 2013, June 2015

Flown in Aircraft Certified for Normal Operations



Evaluated in Flight by Senior Airline Pilots



Operated in Congested Airspace



Also Assessed from ATC Perspective



Tested on Airline Hardware



Data Collection

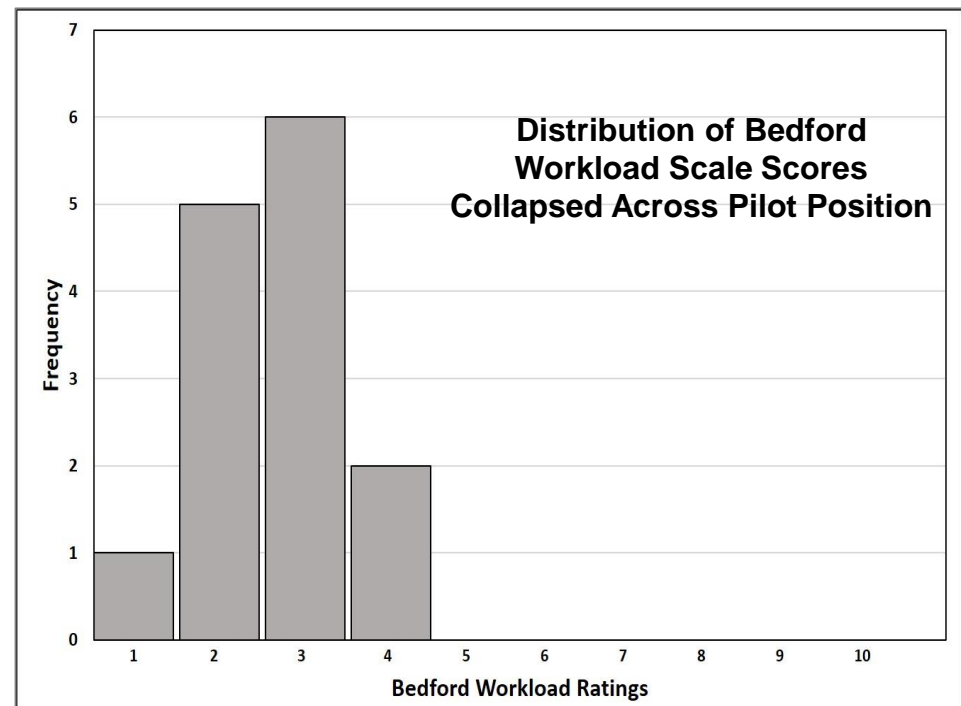
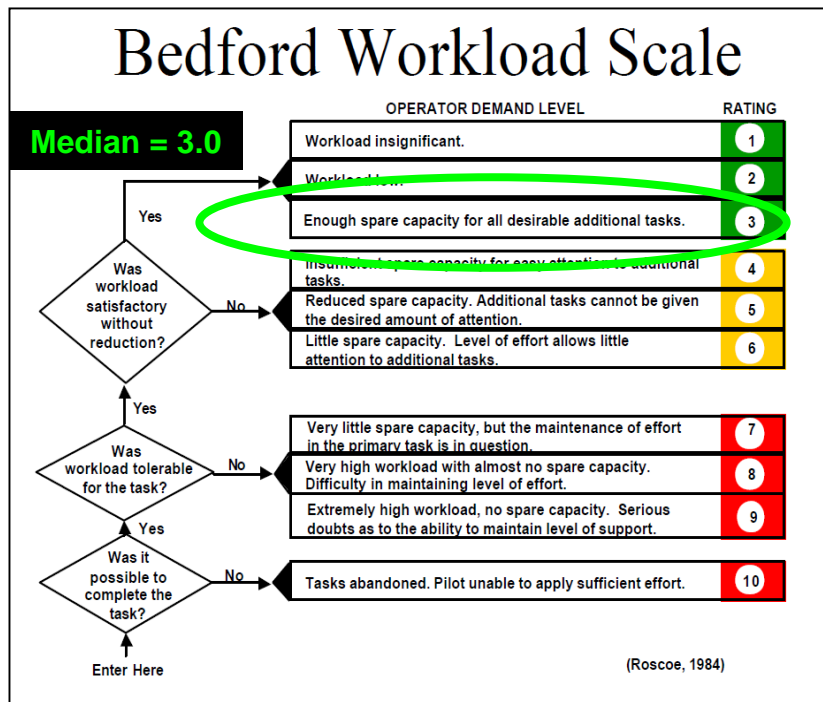
- Two evaluation pilots per flight (cockpit and cabin)
 - 12 flights
 - 2 to 2.5 hours per flight
- Subjective measures administered
 - In flight
 - Post flight

Subjective Measures

- **Bedford Workload Scale.** The Bedford Workload Scale is a uni-dimensional rating scale designed to identify operator's spare mental capacity while completing a task.
- **System Usability Scale (SUS).** The SUS provides a quickly administered and reliable tool for measuring subjective assessments of usability.
- **Situation Awareness Rating Technique (SART).** The SART is a subjective measure of situation awareness that can provide an index of how well operators are able to acquire and integrate information in a complex environment.
- **Post-Flight TAP HMI Evaluation.** This questionnaire consisted of five-point Likert-type rating scales regarding the overall comprehensibility, usability, and usefulness of the TAP HMI as well as questions about specific display features.

Bedford Workload Scale

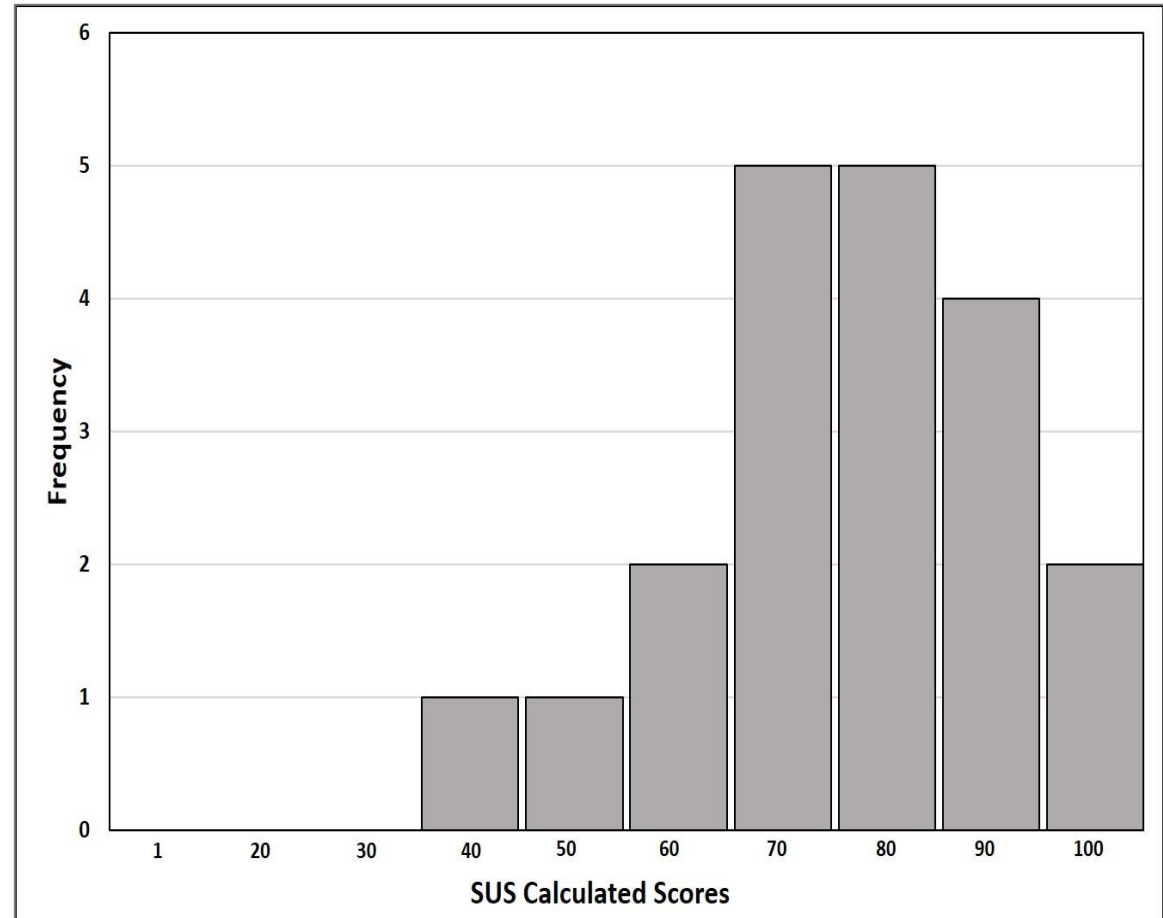
- Evaluation Pilots reported their cognitive workload as low ($M = 2.64$, $SD = 0.84$)
 - Rating of 1 indicating insignificant workload and a rating of 10 indicating a very high level of workload and task abandonment



System Usability Scale

- No significant differences based on pilot position (cockpit vs. cabin)
- SUS calculated scores were collapsed across pilot position
- Pilots reported ratings of high perceived usability ($M = 80.0$, $SD = 14.33$)

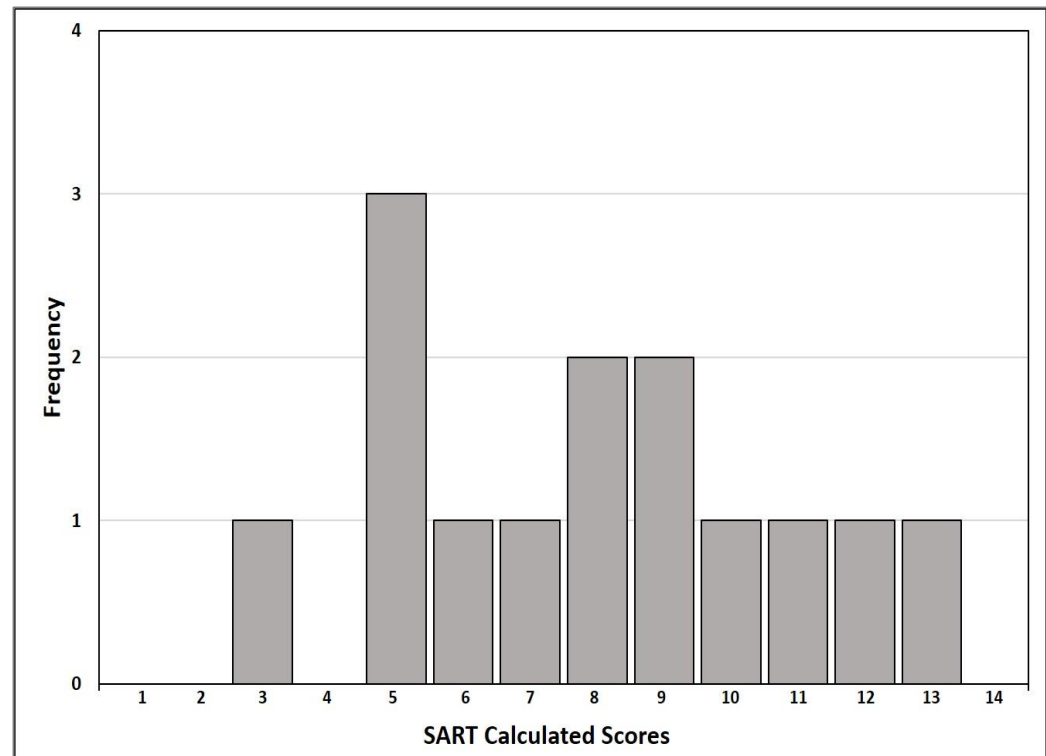
**Distribution of SUS Calculated Scores
Collapsed Across Pilot Position**



Situation Awareness Rating Technique

- No significant differences based on pilot position (cockpit vs. cabin)
- SART calculated scores were collapsed across pilot position
- Pilots reported mid-range situation awareness scores ($M = 7.93$, $SD = 2.95$)
 - Indicates that situation awareness in the cockpit was not affected, either positively or negatively, by interacting with the TAP HMI

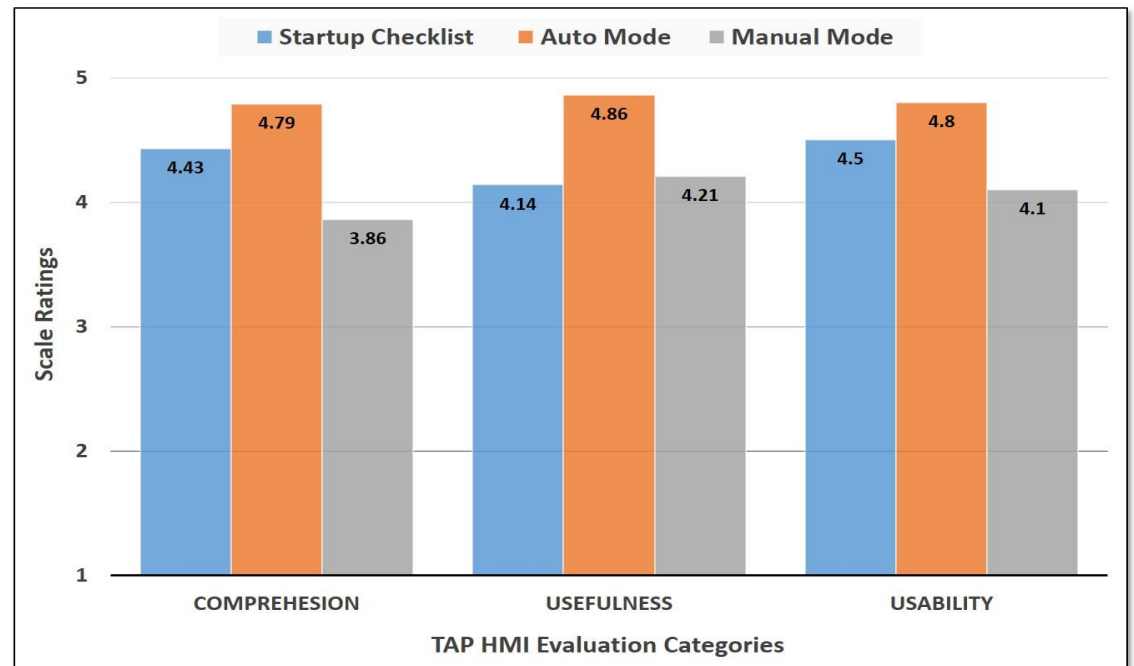
**Distribution of SART Calculated Scores
Collapsed Across Pilot Position**



TAP HMI Evaluation

- Startup Checklist and Auto Mode Screens comprehension was either “Easy” (2) or “Very Easy” (1)
 - $M = 4.43, 4.79$; $SD = 0.76, 0.43$
- Manual Mode Screen slightly less comprehensible, with 43% of pilots reporting that comprehension was “Somewhat Easy” (3)
 - $M = 3.86$, $SD = 0.86$
- All three display screens were found to be either
 - “Useful” or “Very Useful” and
 - “Usable” or “Very Usable”

Overall HMI Evaluation Ratings - TAP Display Screens



Conclusions

- Interaction with the TAP HMI did not create a significant level of additional workload and generally did not inhibit successful completion of tasks
- TAP HMI has a high degree of comprehensibility, usefulness, and usability
- Pilot situation awareness, as rated in flight, was not affected either positively or negatively by interacting with the TAP HMI
 - However, when asked post-flight, the pilots indicated that TAP enhanced their situation awareness
- Results are being used to further refine and improve the capabilities and features of the TAP HMI in preparation for operational trials with partner airlines planned for 2017-2018

Questions?

